Eastern Asia as the source of civilization. The root *ma* in Chinese, signifies "a horse; enraged; martial-like," and it might easily be presumed that the name of Mars was derived from the same root. This coincidence of etymological forms, taken in connection with the well-known fact, that the Phenicians had a perfect alphabet at a time when the use of hieroglyphics in Egypt was nearly or quite universal, may prove to be of some importance.

Prof. Booth, Mr. Foulke, Prof. Coppée, the Rev. Mr. Barnes, Dr. Coates, Prof. Lesley, and Dr. Bache continued the discussion of the subject.

Prof. Booth invited the attention of the members present to the analysis of Delaware and Schuylkill water, by Profs. Booth and Garrett, on page 75 of the lately published Report of the Chief Engineer of the Philadelphia Water Works for 1862.

Pending nominations Nos. 481 to 483, and new nominations Nos. 484 to 490, were read.

The resolutions postponed from the last meeting were laid on the table.

And the Society was adjourned.

Stated Meeting, March 6, 1863.

Present, eighteen members.

Dr. Wood, President, in the Chair.

Letters accepting membership were received from M. J. Boucher de Perthes, President of the Imperial Society of Emulation, at Abbeville, in France, dated February 9th; from M. Fréderic Troyon, of Lausanne, in Switzerland, dated February 10th, and from Dr. A. A. Henderson, U. S. N., dated United States Steam Sloop Richmond, New Orleans, February 20th, 1863.

Donations for the Library were received from Prof. Secchi, the Royal Astronomical and American Oriental Societies, the Academy of Natural Sciences at Philadelphia, Messrs. Blanchard & Lea, Dr. I. I. Hayes, and Sidney George Fisher, of Philadelphia, Dr. Lewis H. Steiner, of Baltimore, Mr. Gowan, bookseller, of New York, Bishop Duggan, of Chicago, and the Librarian of the University of Michigan.

A copy of the Transactions, Vol. XII, Part iii, was laid on the table.

Prof. Coppée read the following obituary notice of General O. McK. Mitchel.

BIOGRAPHICAL NOTICE.

The subject of this sketch had achieved such brilliant success in science and in arms, that the detailed story of his life would be read with eager interest by his admiring countrymen. It is to be hoped that such a biography will not be withheld; not alone in eulogy of his virtues and his achievements, but as a bright example to ourselves and to our children. It is not, however, the purpose of the writer, here and now, to present these details. It is only intended to glance at the principal objective points in his eager, ardent, devout, and energetic life.

Ormsby McKnight Mitchel was born in Union County, Kentucky, on the 28th of August, 1810. He had the misfortune to lose his father when he was three years old, and thus, from his early infancy, he was left to battle with the world, and win such a place in its esteem, as the God-given genius and indomitable energy he possessed might secure for him. Immediately after his father's death, his family removed to Ohio; and at twelve years of age, he became a clerk in a store in the town of Miami, whence, however, not long after, he moved with his family to Lebanon. A bright and inquiring boy, he soon found the plodding and menial duties of a country store tame, painful, and unsatisfactory.

Always eager in the pursuit of learning, and especially of that practical knowledge which could clear the wilderness, and build towns like magic in our then wild as well as far West, he bent his energies towards procuring an appointment to the Military Academy at West Point, where, he had been told, such instruction was given at the expense of the Government, and an assured future lay beyond to the honorable graduate. He was successful; he entered the Military Academy on the 23d of June, 1825, when not yet fifteen years old,—

being admitted, by special favor, a year earlier than the law allowed. His standing while a cadet was always high, and his pursuit of knowledge, in all its forms, eager and persevering. Among his classmates were the most distinguished generals at present in our own or the rebel service; among the latter were Lee and Joseph Johnston. His letters to his mother and brother during this period, all represent him as an eager student and ambitious in his aims.

In 1829, he graduated with honor, and was appointed a second lieutenant in the Second Artillery. So favorable was the impression produced by his novitiate, that he was very soon detailed for duty at the Academy, as Assistant Professor of Mathematics. He was afterwards, for a short time, stationed at St. Augustine, in Florida. But the prospects of the army at that period could not satisfy the energy and honorable ambition of such a man as Mitchel. He resigned on the 30th of September, 1832, with no fortune, and no prospect but in persevering labor, to achieve fame, usefulness, and honor.

Just after his graduation, the French Revolution broke out,—those "three days of July" which drove the "legitimate" Bourbons once more from the throne they were unworthy to occupy, and elevated the citizen-king, Louis Philippe, to the seat of power. Many remember the effect produced by this volcanic eruption all over the civilized world. It is worthy of record, as illustrative of his character, that our young soldier was not exempt from the pervading influence. His letters to his brother express an unsettled condition of mind, and a growing desire to go to Europe and plunge, sword in hand, into the great wars which he believed would grow out of this change of dynasty. This is mentioned as betokening his quickly kindled enthusiasm, his desire to exercise his newly-acquired powers, and his ardent but honorable ambition for distinction. The spirit of revolution which France evoked, and which stalked for a brief space through Europe, was soon laid, and Mitchel settled, as has been told, into the quiet but hard-working life of a citizen.

While in the army, he had married Mrs. Trask, the widow of Lieutenant Trask, and formerly Miss Louisa Clark, of Cornwall, on the Hudson. In his growing family he found new incentives to labor, and so we see him, in 1832, opening an office as counsellor-at-law in Cincinnati. In this position he remained until the establishment of the Cincinnati College, in 1834, when he was elected Professor of Mathematics, Philosophy, and Astronomy. This post he held until the sad and untimely destruction of the College buildings by fire, and the consequent dissolution of the College. But what seemed his misfortune was in reality a great blessing. In the routine of academic duties he might have remained satisfied; but when once more thrown upon his own remarkable energies, his "sleepless soul" undertook grand and original adventures.

During the period of his professorship, he could still find time to devote to other public duties. From 1836 to 1837, he was Chief Engineer of the Little Miami Railroad. He had, while in the army, acquired some experience in railway engineering, which was to prove of value on many occasions during his life of peace, and to find brilliant opportunities during his brief but splendid military career. But his principal study was astronomy, the objective science which kindled his ardor and claimed all his devotion. Amid the drudgery of the lawyer's office; while teaching the elements of mathematics and mechanics; in the practical, busy life of a railway engineer, the stars shone upon him with that potent *influence* with which, in earlier days, they had been supposed to shine upon every man. For him, we may almost believe, there was a horoscope, and that all the planets were conjoined in its composition.

In 1842, he undertook to establish the Cincinnati Observatory, now Mitchel's Observatory, a gigantic labor, which would have been too much for talent, energy, and industry less than his own. Of the difficulties which he encountered, we may best judge by his own narrative. Writing in 1848, he says: "My attention had been for many years directed to this subject (the erection of a great astronomical observatory in the city of Cincinnati), by the duties of the professorship, which I then held in the College. In attempting to communicate the great truths of astronomy, there were no instruments at hand to confirm and fix the wonderful facts recorded in the books. Up to that period, our country, and the West particularly, had given but little attention to practical astronomy. A few individuals, with a zeal and ardor deserving of all praise, had struggled on to eminence almost without means or instruments. An isolated telescope was found here and there scattered through the country; but no regularly organized observatory, with powerful instruments, existed within the limits of the United States, so far as I know. . . .

"To ascertain whether any interest could be excited in the public mind in favor of astronomy, in the spring of 1842, a series of lectures was delivered in the hall of the Cincinnati College. To give an increased effect to these discourses (which were unwritten, and in a style of great simplicity), a mechanical contrivance was prepared, by the aid of which the beautiful telescopic views in the heavens were presented to the audience, with a brilliancy and power scarcely inferior to that displayed by the most powerful telescopes. To this fortunate invention were these lectures ('The Planetary and Stellar Worlds'), no doubt, principally indebted for the interest which they produced, and which occasioned them to be attended by a very large number of the intelligent persons in the city. Encouraged by the large audiences, which continued through two months to fill the lecture-room, and still more by the request to repeat the last lecture of the course in one of the great churches of the city, I matured a plan for the building of an observatory, which it was resolved should be presented to the audience at the close of the lecture, in case circumstances should favor. . . .

"Such is the history of the origin of the Cincinnati Astronomical Society. . . .

"Under its auspices, I started for New York, and on the 16th of June, 1842, sailed for Liverpool. Having visited many of the best appointed observatories both in England and on the Continent (in each and every one of which I was received with a degree of kindness and attention, for which I acknowledge the deepest obligations), and having been unsuccessful in finding, either in London or Paris, an object-glass of the size required, I finally determined to visit the city of Munich. The fame of the optical institute of the celebrated Frauenhofer had even reached the banks of the Ohio, and it was hoped that in that great manufactory, an instrument such as the Society desired might be obtained, if not completed, at least in such a state of forwardness as to permit it to be furnished at an early day. In this I was not disappointed. An object-glass of nearly twelve inches diameter, and of superior finish, was found in the cabinet of M. Mertz, the successor of Frauenhofer. This glass had been subjected to a severe trial in the tube of the great refractor of the Munich Observatory, by Dr. Lamont, and had been pronounced of the highest quality.

"To mount this glass would require about two years, at a cost of nearly ten thousand dollars; a sum considerably greater than that appropriated at the time for an equatorial telescope. Having made a conditional arrangement for this and other instruments, I returned to Greenwich, England, where, at the invitation of Professor Airey, the Astronomer Royal, I remained for some time to study. Having accomplished the objects of my journey, I returned home, and rendered a report to a very large meeting of the members of the Association, and other citizens of Cincinnati. . . .

"The principal instrument having been ordered, and the first payment on its cost made, attention was now given to the procuring of a suitable site for the building. Fortunately for the Society, the place of all others most perfectly adapted to their wants, was then the property of Nicholas Longworth, Esq. It is a lofty hill-top, rising some four hundred feet above the level of the city, and commanding a perfect horizon in all directions. On making known to Mr. Longworth the prospects and wants of the Astronomical Society, the writer was directed by him to select *four acres* on the hilltop, out of a tract of some twenty-five acres, and to proceed at once to inclose it, as it would give him great pleasure to present it to the Association. On compliance with the conditions of the title bond, a deed has since been received, placing the Society in full possession of this elegant position. . . . .

"At length the building was reared, and finally covered in, without incurring any debt. But the conditions of the bond, by which the lot of ground was held, required the completion of the Observatory in two years from its date, and these two years would expire in June, 1845. It was seen to be impossible to carry forward the building fast enough to secure its completion by the required time, without incurring some debt. My own private resources were used, in the hope that a short time after the finishing of the Observatory, would be sufficient to furnish the funds to meet all engagements. The work was pushed rapidly forward. In February, 1845, the great telescope safely reached the city of Cincinnati, and in March the building was ready for its reception. I had now exhausted all my private means, and to increase the difficulty of the position in which I was placed, the College edifice took fire, and burned to the ground. My ordinary means of support were thus destroyed at a single blow. I had engaged to conduct the Observatory, without compensation from the Society, for ten years, in the hope that my College salary would be sufficient for my wants. It was impossible to abandon the Observatory. The College could not be rebuilt, at least, for several years, and in this emergency, I found it necessary to seek some means of support, least inconsistent with my duties in the Observatory. My public lectures at home had been comparatively well received, and after much hesitation, it was resolved to make an experiment elsewhere. For five years I had been pleading the cause of science among those little acquainted with its technical language. I had become habituated to the use of such terms as were easily understood; and probably to this circumstance more than to any other one thing, am I indebted for any success which may have attended my public lectures. To the citizens of Boston, Brooklyn, New York, and New Orleans, for the kindness with which they were pleased to receive my imperfect efforts, I am deeply indebted. My lectures were never written, and no idea was entertained of publishing a course, until the partiality of my friends induced me to attempt this experiment."

Thus it was that, in 1842, he began his remarkable career as a lecturer on astronomy. More than any other man in America has he thus accomplished for his favorite science. Besides the Observatory he founded, and the instruments he imported, and to which he has greatly added by his improvements and inventions, he awakened in thousands of minds an interest in the subject, instructed popular assemblies, not only by his clear outlines of the gigantic science, but by his masterly handling of its difficult and abstruse theories and problems, and by his fiery words, which exhibiting his own knowledge and enthusiasm, told of its divine beauties and relations, and kept crowded audiences all over the country in breathless and delighted attention.

He found time to begin, in 1846, the publication of the Siderial Messenger, a popular astronomical monthly, which was regularly issued for more than a year.

He had surveyed the Ohio and Mississippi Railroad in 1844, and when the enterprise was fairly undertaken, and the road placed under contract, he was sent to Europe by the Company, as a confidential agent on the business of the road, in 1853, and again on the same business in 1854. For some time he was the President of the Cincinnati division of that road, and was chiefly instrumental in bringing it to a successful completion.

In the summer of 1860, he was appointed Director of the Dudley Observatory, and, without a reference to the unhappy difficulties which beset that institution at the beginning, it may be said that his acceptance of the post restored quiet, and produced the greatest usefulness of which the Observatory was instrumentally and financially capable. It was still under his direction at the time of his death.

When the war broke out, Professor Mitchel, urged singly and purely by patriotic motives, placed his services at the disposition of the Government, and devoted his life and military knowledge to his country. On the 9th of August, 1861, he was appointed a Brigadier-General of Volunteers, and was placed in command of the Department of the Ohio, with his headquarters at Cincinnati. While there he carefully surveyed the approaches to the town, and built redoubts and projected defences at the prominent points, which doubtless served a good purpose when, at a later day, Cincinnati was threatened by an overwhelming rebel force.

When the Departments of the Ohio and the Cumberland were afterward united, General Mitchel was ordered to report to General Buell; and he was then placed in command of a camp of rendezvous, where he was actively receiving, organizing, and forwarding troops for three weeks. At the expiration of this brief period, he was appointed to the command of the Third Division of the Army of the Ohio, then stationed at Elizabethtown, Kentucky. If we particularize in dates and positions, it is that the reader may trace the rapid and energetic movements of General Mitchel the more intelligibly.

On the 9th of February, 1862, he was at Bacon Creek; on the 13th he started for Bowling Green, until then the strongest point on the strategic line of the rebel army. Forced marches, in themselves a wonderful feat with new troops, brought him to Bowling Green on the 15th. On the 22d, he started with General Buell for Nashville; and it is worth recording that that city was surrendered to Colonel Kennett, of the Fourth Ohio Calvary, for General Mitchel, on Sunday evening, February 23d. The surrender is publicly believed to have been made to General Nelson, but that officer did not arrive with his division to occupy the place until three days after it had capitulated to General Mitchel. He had now entered upon those brilliant independent movements which had excited the admiration of the whole country, and which, could he have received timely and adequate reinforcements, would have redeemed the entire region in which they were made. Early in March, he was at Murfreesboro', where, putting his railroad experience in practice, he improvised twelve hundred feet of bridges. Leaving Murfreesboro' on the 6th of April, he marched to Shelbyville; on the 10th, he was at Fayetteville; and on the 11th, at Huntsville, in Alabama. Here, again, the railway engineer supplied valuable generalship. Seizing the rolling stock, he immediately sent out two railway expeditions, east and west, the one to Decatur, and the other to Stevenson, on the Memphis and Charleston Railroad. The expedition to Stevenson he conducted in person. Both places were captured, and Northern Alabama was in Federal possession, one hundred and twenty miles of the railroad being in running condition, and guarded by Mitchel's troops.

For this brilliant achievement, he was made a Major-General of Volunteers, to date from April 11th, the day of the capture of Huntsville.

On the 2d of July, General Mitchel was ordered to report himself at Washington. He was there in person on the 5th. From that time he was waiting for orders until September 12th, when he started for the important command of the Tenth Army Corps, the head-quarters of which were at Hilton Head, South Carolina. He reached there on the 16th. His coming infused new life into the department, and he was maturing his plans for a grand movement, when he was called away from earth. He sent an expedition to St. John's River, which captured the fort, with many heavy guns; and also a force to Pocotaligo, for the purpose of destroying the Charleston and Savannah Railroad and telegraph, in which it was successful. He also drew Beauregard out of Savannah with twenty-five thousand men. What he further intended cannot be told, but every day, had he lived, would have disclosed the character of his projects, of which these movements were but the initiation.

While in the midst of his usefulness and rapidly maturing plans, he was attacked by the yellow fever on Sunday, the 26th of October, and died on October 30th, 1862, in Beaufort, South Carolina.

Such, briefly, is the record of his life. The meagre recital is full of valuable lessons, and leads the scholar, the patriot, the soldier, and the Christian to moralize upon the great loss the country has sustained, while they eulogize his genius, his talents, his virtues, his piety, and his lofty achievements. Few men of our age have exhibited a more extended genius, and we know of no one who has displayed so much energy in everything he has undertaken. His character will bear minute analysis; in every department of labor he was successful; in many he was truly eminent.

As a *man of science*, Professor Mitchel was an ardent investigator, and an eminently practical inventor. Fully imbued with the poetry of science, delighting in the lofty picturesques of astronomic thought, abounding in the rarest imagery in his public teachings, his true sphere was in the mechanism of the means for scientific observation and labor. To prepare himself as director of the Observatory, he had studied and mastered the higher astronomical mathematics, and was thoroughly conversant with the history of the science. To qualify himself as a public teacher, he had resolved the most difficult problems into such simple forms and such lucid language, as to make them clear to many who had regarded it impossible to comprehend them. To give himself facility in observing, he had studied under Professor Airey, the Astronomer Royal of England at Greenwich; and to understand the scientific relations of astronomy as they appear in the cosmogony of the universe, he had investigated those sister sciences which, while they are elements of the great subject, come forward in their progress of development to cast their tribute at the feet of Him who dictated the record of Moses.

As a mechanical inventor, he may be best presented by placing in this connection, some account of the principal instruments which he created for facilitating observations.

The following description of the Declinometer is furnished through the kindness of Mr. G. W. Hough, the astronomer in charge of the Dudley Observatory:

"Method invented by Professor Mitchel for determining difference of declination.

"The apparatus for observing difference of declination consists of the following:

"To the axis of the transit telescope is attached a metallic arm of sixty inches in length; in the lower end of this arm is screwed a cylindrical pin, one-eighth of an inch in diameter, at right angles to the arm and parallel to the supporting axis of the telescope. This pin has a notch or groove (of the form which would be generated by placing the vertices of two isosceles triangles together, and revolving about the perpendicular), cut in the middle.

"At a distance of twenty-three inches from the pin, and in the same horizontal plane, is mounted in Y's a small telescope of six inches focal length. The supporting axis of this telescope is parallel to that of the transit. Underneath the centre of the small telescope, and connected with it, is a short arm two inches in length, and by means of a joint, a rod is connected with the pin before mentioned.

"Now when the transit telescope is moved in zenith-distance, angular motion is given to the small telescope, by means of the long arm and connecting-rod.

"The amount of this motion is read from a scale, placed at a distance of fifteen feet, and divided to single seconds of arc. It will, of course, be understood that we must have some object in the focus of the small telescope with which to compare the divisions of the scale. We use either a cross formed by the intersection of two spider's webs, or a single horizontal wire.

"In case we wish to observe a zone of greater width than the extent of the scale (30′), we have a number of pins, at distances of

30′ apart, mounted in the arc of a circle whose radius is equal to the length of the long arm. We readily pass from one pin to another, by lifting one end of the connecting-rod, and attaching it to a different one. The divisions on the scale can easily be read by estimation, to two-tenths of a second of arc.

"The time required to read the scale is much less than that employed in reading *one* microscope, since at the same transit of an equatorial star we can make from ten to fifteen bisections and readings. As I have found one reading of the scale nearly equal to four microscopes, it follows that if we employ the same time in the observation of an object with the Declinometer that we do when we use the Circle, our results in the former case will be superior to the latter in a large ratio.

"The Zone observations with the Declinometer have been made mostly for the investigation of the source and amount of error due to this method. From a comparison of the observations with those made in the ordinary way, I find the probable error, on a single observation, falls within the limits of accuracy usually assigned to observations made with the Meridian Circle. One great advantage lies in the fact that many bisections and readings can be made at the same transit, and in this way eliminating the ordinary errors of observation. You will understand the rapidity with which work can be done by this method, when I state that more than two hundred stars have been accurately observed in one hour; and were they equally distributed, twice that number could easily have been taken.

"This instrument is one of the great inventions of our late and lamented director, Professor Mitchel, and is the only one in the world.

"From observations made during the last two years, and a careful discussion of the results, I have arrived at the conviction *that there is no other known method equal to it, for rapidity and accuracy, in the cataloguing of stars.*"

Professor Mitchel's remarkable mechanical skill, his quickness to perceive difficulties, and the readiness with which he devised and applied the remedies, are further admirably illustrated in his apparatus for recording time by means of the electro-magnetic telegraphs. These are now in use in the Cincinnati and Dudley Observatories. His was the first thorough solution of this important problem in instrumental astronomy. The following account of this apparatus is in Professor Mitchel's own words :

"The problem of causing a clock to record its beats telegraphically, was nothing more than to contrive some method whereby the clock might be made (by the use of some portion of its own machinery) to take the place of the finger of the living, intelligent operator, and 'make' or 'break' the electric circuit. The grand difficulty did not lie in causing the clock to play the part of an automaton in this precise particular, but it did lie in causing the clock to act automatically, and at the same time perform perfectly its great function of a timekeeper. This became a matter of great difficulty and delicacy; for to tax any portion of the clock machinery with a duty beyond the ordinary and contemplated demands of the maker, seemed at once to involve the machine in imperfect and irregular action. After due reflection it was decided to apply to the *pendulum* for a minute amount of power, whereby the making or breaking the electric circuit might be accomplished with the greatest chance of escaping any injurious effects on the going of the clock. The principle which guided in this selection was, that we ought to go to the prime mover (which in this case was the clock weights, and which could not be employed), and failing to reach the prime mover, we should select the nearest piece of mechanism to it, which in the clock is the pendulum. A second point early determined by experiment and reflection was this: that the making or breaking of the circuit must be accomplished by the use of mercury, and not by a solid metallic connection. Various methods were tried, and soon abandoned as uncertain and irregular in their results, and the following plan was adopted:

"A small cross of delicate wire was mounted on a short axis of the same material, passing through the point of union of the four arms constituting the cross. This axis was then placed horizontal on a metallic support in Y's, where it might vibrate, provided the top stem of the cross could be in some way attached to the pendulum of the clock, and the 'cross' should thus rise and fall at its outer stem as the pendulum swings backward and forward. The metallic frame bearing the 'cross' also bore a small glass tube bent at right angles. This was filled with mercury, and into one extremity one wire from the pole of the battery was made to dip; the other wire was made fast by a binding screw to the metallic stand bearing the 'cross,' and thus every time the 'cross' dipped into the mercury in the bent tube, the electricity passed through the metallic frame, up the vertical standards bearing the axis of the cross, along the axis to the stem, and down the stem into the mercury, and finally through the mercury to the other pole of the battery. Thus at every swing of the pendulum the circuit was made, and a suitable apparatus might, by the electro-magnet, record each alternate second of time.

"The amount of power required of the pendulum to give motion to the delicate wire-cross was almost insensible, as the stems nearly counterpoised each other in every position. Here, however, there was great difficulty in procuring a fibre sufficiently minute and elastic to constitute the physical union between the top stem of the cross and the clock pendulum. Various materials were tried, among others a delicate human hair, the very finest that could be obtained, but this was too coarse and stiff. Its want of pliancy and elasticity gave to the minute 'wire-cross' an irregular motion, and caused it to rebound from the globule of mercury into which it should have plunged. After many fruitless efforts, an appeal was made to an artisan of wonderful dexterity; the assistance of the *spider* was invoked. His web, perfectly elastic and perfectly pliable, was furnished, and this material connection between the wire-cross and the clock pendulum proved to be exactly the thing required. In proof of this remark, I need only state the fact that one single spider's web has fulfilled the delicate duty of moving the wire-cross, lifting it, and again permitting it to dip into the mercury every second of time for a period of more than three years! How much longer it might have faithfully performed the same service I know not, as it then became necessary to break this admirable bond, to make some changes in the clock. Here it will be seen the same web was expanded and contracted each second during this whole period, and yet never, so far as could be observed, lost any portion of its elasticity. The clock was thus made to close the electric circuit in the most perfect manner; and inasmuch as the resistance opposed to the pendulum by the 'wire-cross' was a constant quantity and very minute, thus acting precisely as does the resistance of the atmosphere, the clock, once regulated with the 'cross' as a portion of its machinery, moved with its wonted steadiness and uniformity. Thus one grand point was gained. The clock was now ready to record its own beats automatically and with absolute certainty, without in any way affecting the regularity of its movement. It was early objected to the mercurial connection just described, that in a short time the surface of the mercury would become oxydized, and thus refuse to transmit the current of electricity; but experiment demonstrated that the explosion produced by the electric discharge at every dip into the mercury threw off the oxyd formed, and left the polished surface of the globule of mercury in a perfect state to receive the next passage of the electricity.

"So far as known, all other methods are now abandoned, and the mercurial connection is the only one in use.

"THE TIME-SCALE.—The clock being now prepared to record its beats accurately and uniformly, the next important step was to obtain, if possible, a uniformly moving time-scale, which should be applicable to the practical demands of the astronomer.

"In case the fillet of paper used in the Morse telegraph could have been made to flow at a uniform rate upon its surface, the clock could now record, its beats appearing as dots separated from each other by equal intervals. But it was soon seen that the paper could not be made to flow uniformly; and even had this been possible, a single night's work would demand for its record such a vast amount of paper, that this method was inapplicable to practice. After careful deliberation, the 'revolving disk' was selected as the best possible surface on which the record of time and observation could be made. The preference was given to the disk over the cylinder for the following reasons: The uniform revolution of the disk could be more readily reached. The record on the disk was always under the eye in every part of it at the same time, while on the revolving cylinder, a portion of the work was always invisible. One disk could be substituted for another with greater ease, and in a shorter time, and the measure of the fractions of seconds could be more rapidly and accurately performed on the disk than on the cylinder.

"After much thought and experiment, it was decided to adopt 'a make circuit' and 'a dotted scale' rather than a 'break circuit' and a 'linear scale;' and I think it will be seen hereafter that in this selection, the choice has been fully justified in practice. These points being settled, the mechanical problems now presented for solution were the following: First, To invent some machinery which could give to a disk of, say twenty inches diameter, mounted on a vertical axis, a motion such that it should revolve uniformly once in each minute of time; and second, to connect with this disk, the machinery which should enable the clock to record on the disk each alternate second of time, in the shape of a delicate round dot. Third, The apparatus which should enable the observer to record on the same disk the exact moment of the transit of a star across the meridian, or the occurrence of any other phenomenon.

"The first of these problems was by far the most difficult, and indeed, its perfect solution remains yet to be accomplished, though for any practical astronomical purpose, the problem has been solved in more than one way.

"The plan adopted in the Cincinnati Observatory may be described as follows: The clock-work machinery employed to give to the great equatorial telescope a uniform motion equal to that of the earth's rotation on its axis, offered to me the first obvious approximate solution of the problem under consideration. This machinery was accordingly applied to the motion of the disk, or rather to *regulate* the motion of revolution, this motion being produced by a descending weight, after the fashion of an ordinary clock. It was soon discovered that the 'Frauenhofer clock,' as this machine is called, was not competent to produce a motion of such uniformity as was now required. Several modifications were made with a positive gain; but after long study it was finally discovered that when the machinery was brought into perfect adjustment, the dynamical equilibrium obtained was an equilibrium of instability; that is, if from a motion such as produced a revolution in one exact minute, it began to lose, this loss or decrement in velocity went on increasing, or if it commenced to gain, the increment went on increasing at each revolution of the disk. Now all these delicate changes could be watched with the most perfect certainty; as in case the disk revolved uniformly once a minute, then the seconds' dots would fall in such a manner (as we shall see directly), that the dots of the same recorded seconds would radiate from the centre of the disk in a straight line. Any deviation from this line would be marked with the utmost delicacy down to the thousandth of a second. By long and careful study, it was at length discovered, that to make any change in the velocity of the disk, to increase or decrease quickly its motion, in short, to restore the dynamical equilibrium, the winding key of the 'Frauenhofer clock' was the point of the machinery where the extra helping force should be applied; and it was found that a person of ordinary intelligence stationed at the disk, and with his fingers on this key, could, whenever he noticed a slight deviation from uniformity, at once, by slight assistance, restore the equilibrium, when the machine would perhaps continue its performance perfectly for several minutes, when again some slight acceleration or retardation might be required from the sentinel posted as an auxiliary.

"The mechanical problem now demanding solution was very clearly announced. It was this: Required to construct an automaton which should take the place of the intelligent sentinel, watch the going of the disk, and instantly correct any acceleration or retardation. This, in fact, is the great problem in all efforts to secure uniform motion of rotation. This problem was resolved theoretically in many ways, several of which methods were executed mechanically without success, as it was found that the machine stationed as a sentinel to regulate the going of the disk was too weak, and was itself carried off by its too powerful antagonist. The following method was, however, in the end, entirely successful. Upon the axis of the winding key already mentioned, a toothed wheel was attached, the gearing being so adjusted that one revolution of this wheel should produce a whole number of revolutions of the disk. The circumference of this wheel was cut into a certain number of notches, so that as it revolved, one of these notches would reach the highest point once in two seconds of time. By means of an electro-magnet, a small cylinder or roller, at the extremity of a lever arm, was made to fall into the highest notch of the toothed wheel at the end of every two seconds. In case the disk was revolving exactly once a minute, the roller, driven by the sidereal clock, by means of an electro-magnet, fell to the bottom of the notch, and performed no service whatever; but in case the disk began to slacken its velocity, then the roller fell on the retreating inclined face of the notch, and thus urged forward by a minute amount the laggard disk, while on the contrary, should the variation from a uniform velocity present itself in an acceleration, then the roller struck on the advancing face of the notch, and thus tended slowly to restore ths equilibrium. Let it be remembered that this delicate regulator has but a minute amount of service to perform. It is ever on guard, and detecting, as it does instantly, any disposition to change, at once applies its restoring power, and thus preserves an exceedingly near approach to exact uniformity of revolution. This regulator operates through all the wheel-work, and thus accomplishes a restoration by minute increments or decrements spread over many minutes of time.

"With a uniformly revolving disk, stationary in position, we should accomplish exactly and very perfectly, the record of one minute of time, presenting on the recording surface thirty dots at equal angular intervals on the circumference of a circle. To receive the *time dots* of the next minute on a circle of larger diameter, required either that the recording pen should change position, or that at the end of each revolution, the disk itself should move away from the pen by a small amount. We chose to remove the disk. To accomplish accurately the change of position of the disk, at the end of each revolution, the entire machine was mounted on wheels on a small railway track, and by a very delicate mechanical arrangement, accomplished its own change of position between the fifty-ninth and sixtieth second of every minute."

But Professor Mitchel was also a very successful observer. He remeasured Struve's double stars south of the equator, discovered the companion of Antares, and added many new stars to the catalogue.

As a *lecturer*, Professor Mitchel had a remarkable gift. His fervid oratory was natural. It was the truest exemplification of the trite but striking idea of the poet,

> "Thoughts that breathe, and words that burn."

He could make a dry problem in mathematical astronomy so pleasing, by its clear and eloquent presentation, as to enchain a popular assembly, and extort their applause both for problem and lecturer. His language, purely extemporaneous, was beautiful; his figures and illustrations strikingly well chosen, and his voice and manner powerful and overmastering. Sometimes his fervor seemed like a Delphian inspiration, and there are few among those who heard him who can forget the magnificent effects produced by his lectures on astronomy in this and other cities.

As a true and whole-hearted *patriot* he had no superior. Influenced by this spirit, he tore himself from home ties, alas! not capable of bearing the rude parting, for his departure cost him his cherished wife,—and thus he gave himself up to his country. All his energies, all his talents, his varied education, his fame, his brilliant future,—whatever there was of power or influence in him or his name was hers, devoted to her with a single eye and a single purpose. And he died for her as truly, as devotedly,—shall we not say as gloriously,—as though he had fallen leading a forlorn hope to turn disaster into victory?

But as a *soldier*, his whole-hearted patriotism was of great value. Bred at West Point, and having engrafted upon that thorough elementary education the knowledge of men, of life, of practical science and industrial arts, he was the very *beau-ideal* of a general. Full of resources, he made bridges of cotton bales and fence rails, and was the first man across to test their precarious structure. Restlessly energetic, his mind passed like lightning over every part of a plan or a field; his quick glance caught the capabilities of a position; his experience provided whatever was needed; his surplus vitality, overflowing his own person, swept out among the soldiers, and put the whole mass in motion. His great personal bravery was a constant example and incentive to every man under his command. Wherever he appeared, there was work to do,—expeditions, rapid movements, concerted combinations, forced marches. Without making too sweeping a remark, we may consider General Mitchel as among the very best of our commanders; and had he lived, he would have risen to a position in public esteem and confidence second to none in the land.

As a devout Christian,—not presented now to the world in the mere statement of a charitable opinion, which gives "a good conscience" to every public man who dies,—but as a consistent, conscientious, devout Christian man, General Mitchel is best known to his home and his intimate friends. Admiring, as they do, his brilliant qualities, his learning, his genius, his military fame, they recur with far more comfort to the fact of his holy and fervent life, his daily communion with his God, his practical piety, his certain and holy hope of eternal life through the blood of Christ.

No king stood by his dying bed beseeching him,

> "If thou think'st on Heaven's bliss,
> Hold up thy hand, make signal of thy hope."

Prompted by the unutterable thoughts which crowded upon him, he gave unbidden such a happy signal, literally holding up his hand, and pointing to that world beyond the skies, which was then lifting "its everlasting portals high" to greet him with an immortal radiance, such as even his enthusiastic astronomy had never conceived. His last words, brokenly uttered, were taken down by his aide-de-camp, and add another to the ever-increasing and enduring testimonies, that when the good man dies, God alone is great, and Heaven alone is real existence.

General Mitchel had filled many offices and posts, and was, as might be expected, the recipient of many honors due to his own merits. A graduate of West Point, he was a lieutenant of artillery, a lawyer, a railway engineer, an astronomer, the founder of one observatory, the director of two; a Doctor of Laws from more than one institution; a Fellow of the Royal Astronomical Society, and of several other foreign societies; a Major-General of Volunteers.

In 1841, he was appointed by the President a member of the Board of Visitors to the Military Academy. In 1847 and 1848, he was Adjutant-General of Ohio. In 1848, he published a work called "The Planetary and Stellar Worlds," containing a popular exposition of the important discoveries of modern astronomy. In 1860, his "Popular Astronomy" appeared, a concise elementary treatise on our sun, planets, satellites, and comets; and there is now passing through the press, to be published at an early day, a volume called "The Astronomy of the Bible," in which he endeavors to show that science and revelation may be made eventually to harmonize perfectly.

He was elected a member of the American Philosophical Society in 1853.

Pending nominations Nos. 481 to 490, and new nomination No. 491 were read.

And the Society was adjourned.

Stated Meeting, March 20, 1863.

Present, seventeen members.

Dr. Wood, President, in the Chair.

A letter accepting membership was received from Josiah D. Whitney, lately elected, dated San Francisco, February 13, 1863.

Letters acknowledging the receipt of copies of the Transactions and Proceedings were received from the London Society of Antiquaries, February 27th; the Newcastle Natural History Society, February 24th; the National Museum of Scotland, January 24th; the Massachusetts Historical Society, February 19th and March 16th; the Austrian Consulate at New York, March 19th; the Pennsylvania Historical Society, March 13th; Dr. Charles M. Wetherill of the Agri-